size of a rodent in northcentral Chile. *J. Raptor Res.* 29:245–249.

DICKMAN, C.R., M. PREVADEC AND A.J. LYNAM. 1991. Differential predation of size and sex classes of mice by the Barn Owl, *Tyto alba*. *Oikos* 62:67–76.

FULK, G.W. 1976. Owl predation and rodent mortality: a case study. *Mammalia* 40:423–427.

GREEN, A. AND D.L. JAMESON. 1975. An evaluation of the zygomatic arch for separating juvenile from adult cotton rats (*Sigmodon hispidus*). *J. Mammal.* 56:534–535.

JAKSIC, F.M. 1989. What do carnivorous predators cue in on: size or abundance of mammalian prey? A crucial test in California, Chile, and Spain. *Rev. Chil. Hist. Nat.* 62:237–249.

———. 1997. Ecología de los vertebrados de Chile. Ediciones Universidad Católica de Chile, Santiago, Chile.

———, J.E. JIMENEZ, S.A. CASTRO AND P. FEINSINGER. 1992. Numerical and functional response of predators to a long-term decline in mammalian prey at a semi-arid Neotropical site. *Oecologia* 89:90–101.

KOTLER, B.P. 1985. Owl predation on desert rodents which differ in morphology and behavior. *J. Mammal.* 66:824–828.

———, J.S. BROWN, R.J. SMITH AND W.O. WIRTZ. 1988. The effects of morphology and body size on rates of owl predation on desert rodents. *Oikos* 53:145–152.

LONGLAND, W.S. AND S.H. JENKINS. 1987. Sex and age affect vulnerability of desert rodents to owl predation *J. Mammal.* 68:746–754.

MARTI, C.D. AND J.C. HOGUE. 1979. Selection of prey by size in screech owls. *Auk* 96:319–327.

———, E. KORPIMÄKI AND F.M. JAKSIC. 1993. Trophic structure of raptor communities: a three-continent comparison and synthesis. Pages 47–137 *in* D.M. Power [ED.], Current ornithology. Vol. 10. Plenum Publishing Corporation, New York, NY U.S.A.

SOKAL, R.R. AND F.J. ROHLF. 1981. Biometry. W.H. Freeman and Co., San Francisco, CA U.S.A.

VARGAS, J.M., L.J. PALOMO AND P. PALMQUIST. 1988. Predación y selección intraespecífica de la lechuza común (*Tyto alba*) sobre el ratón moruno (*Mus spretus*) *Ardeola* 35:109–123.

WILSON, D.S. 1975. The adequacy of body size as a niche difference. *Am. Nat.* 109:769–784.

ZAMORANO, E., L.J. PALOMO, A. ANTUNEZ AND J.M. VARGAS. 1986. Criterios de predación selectiva de *Bubo bubo* y *Tyto alba* sobre *Rattus*. *Ardeola* 33:3–9.

Received 17 May 1998; accepted 7 March 1999.

J. Raptor Res. 33(2):172–175

SPATIAL AND TEMPORAL VARIATIONS IN THE DIET OF THE COMMON KESTREL (*FALCO TINNUNCULUS*) IN URBAN ROME, ITALY

EMANUELE PIATTELLA
Dipartimento di Biologia Animale e dell'Uomo (Zoologia), Università di Roma "La Sapienza" Viale dell'Università 32, I-00185 Rome, Italy

LUCA SALVATI
Piazza F. Morosini 12, I-00136 Rome, Italy

ALBERTO MANGANARO
Via di Donna Olimpia 152, I-00152 Rome, Italy

SIMONE FATTORINI
Dipartimento di Biologia Animale e dell'Uomo (Zoologia), Università di Roma "La Sapienza" Viale dell'Università 32, I-00185 Rome, Italy

KEY WORDS: *Common Kestrel*; Falco tinnunculus; *diet*; *avian prey*; *urban area*; *Rome, Italy*.

Several studies have described the ecology of raptors in urban areas (e.g., Galeotti 1994). Common Kestrels (*Falco tinnunculus*) breed in many European towns, frequently occurring in urban areas in higher densities than in farmland areas (Village 1990, Shrubb 1993). Nevertheless, few studies have described details of the feeding ecology of kestrels in these urban areas (Quere 1990, Romanowski 1996). Therefore, the aim of our study was to describe the composition of the kestrel diet and any sea-

Table 1. Common Kestrel (*Falco tinnunculus*) diet in urban Rome, Italy.

	Summer				Winter			
	Prey Number (%)		Prey Biomass (%)		Prey Number (%)		Prey Biomass (%)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stylommatophora	0.6	1.3	0.1	0.3	0.1	0.2	0	0.1
Scorpiones	0.2	0.6	0	0	0	0	0	0
Mantodea	0	0	0	0	0.5	1.1	0.1	0.4
Orthoptera	5.2	4.4	0.4	0.4	22.1	12.8	3.1	3.2
Dermaptera	0.4	1.0	0	0	1.2	2.6	0	0
Coleoptera	29.3	11.9	1.4	0.8	30.9	14.7	1.9	0.8
Hymenoptera	0.1	0.2	0	0	2.7	4.6	0	0
Unidentified insects	0.3	0.5	0	0	0.1	0.2	0	0
Sauria	15.1	6.1	7.2	4.7	9.6	7.9	5.8	4.5
Columbiformes	0.9	1.4	10.8	15.8	0.1	0.2	3.2	5.6
Apodiformes	4.8	5.4	9.4	10.6	0.3	0.9	1.1	2.9
Passeriformes	21.7	9.6	41.6	15.4	4.4	2.8	16.4	10.0
Unidentified birds	2.4	4.1	5.3	10.4	0.1	0.2	0.3	0.8
Insectivora	0	0	0	0	0.5	0.5	0.2	0.3
Chiroptera	7.0	9.7	4.1	6.5	0.6	0.8	0.4	0.6
Rodentia	12.1	6.6	19.6	12.6	26.8	8.7	67.3	15.5
Total prey	1123		16 504 g		1238		11 574 g	

sonal variation in a Mediterranean urban area like Rome, Italy.

Methods

We conducted our study in urban Rome where Common Kestrels occur at higher breeding densities (0.1–2.3 pairs/km^2) than anywhere else in Italy. The kestrels nest in scaffolding holes in Roman ruins and monumental buildings (Salvati and Manganaro 1997). We assessed the diet by analyzing pellets and prey remains collected from 16 sites during the years 1996 and 1997. A total of 13 and 7 pellet samples were analyzed for the spring to summer (breeding period) and winter, respectively. In the city center, pellets were collected every month from April 1996–March 1997.

Pellets and prey remains were dissected in water. Prey remains were identified using diagnostic keys (Manganaro et al. 1990) and by comparison with museum specimens in the Zoology Museum, "La Sapienza" University, Rome, Italy. Mean weights for each prey taxon were estimated using data from Mediterranean areas (Manganaro et al. 1990). The number of individuals (scored as minimum value) was calculated taking into account all different kinds of prey items found. Paired anatomical parts were counted as belonging to the same individual. This method allowed us to estimate the frequency of occurrence of prey numbers (PN) and biomass (PB) for each prey category and to relate PN and PB to the habitat composition of hunting areas.

A Spearman Rank Correlation was used to assess relations among prey numbers for the most important prey categories and between the habitats of hunting areas and prey categories found in the diet during the breeding period, when kestrels generally feed close to nests (Village 1990).

Using the mean size of hunting ranges given in Village (1990) and Shrubb (1993), habitat composition within a 1-km radius of nests (3.14 km^2) was characterized as farmland, wooded, modern urban, and ancient urban. A sequential Bonferroni test (1989) was used to adjust the significance level to the number of comparisons using the same data set. A minimum probability level of $P < 0.05$ was accepted (all tests were two-tailed). Statistical analyses were performed using STATISTICA software (version 4.5, 1993). Results are presented as mean ± SD.

Results

We identified 1123 prey items at breeding diets (86.4 ± 85.9 prey per nest) and 1238 prey items in the winter diets (176.9 ± 120.3 prey per roosting site), for a total biomass of 28 078 g. The number of prey items per pellet varied from 1.6–3.7 in summer ($\bar{x} = 2.8 \pm 0.5$), and from 2.7–4.9 in winter ($\bar{x} = 3.2 \pm 0.7$) ($t = -1.45$, df = 18, $P = 0.165$).

Kestrels preyed on species ranging in size from ants (*Messor* sp., 0.01 g) to adult Feral Pigeons (*Columba livia,* 300 g). Throughout the year, the main prey groups were insects, reptiles, birds, and mammals. Beetles (especially families widely distributed in Mediterranean areas like scarabs and tenebrionids) and birds were most commonly consumed in summer and grasshoppers and small mammals were most common in winter (Table 1). Birds and mammals were the main prey groups by biomass Other prey included molluscs, scorpions, and ants. The

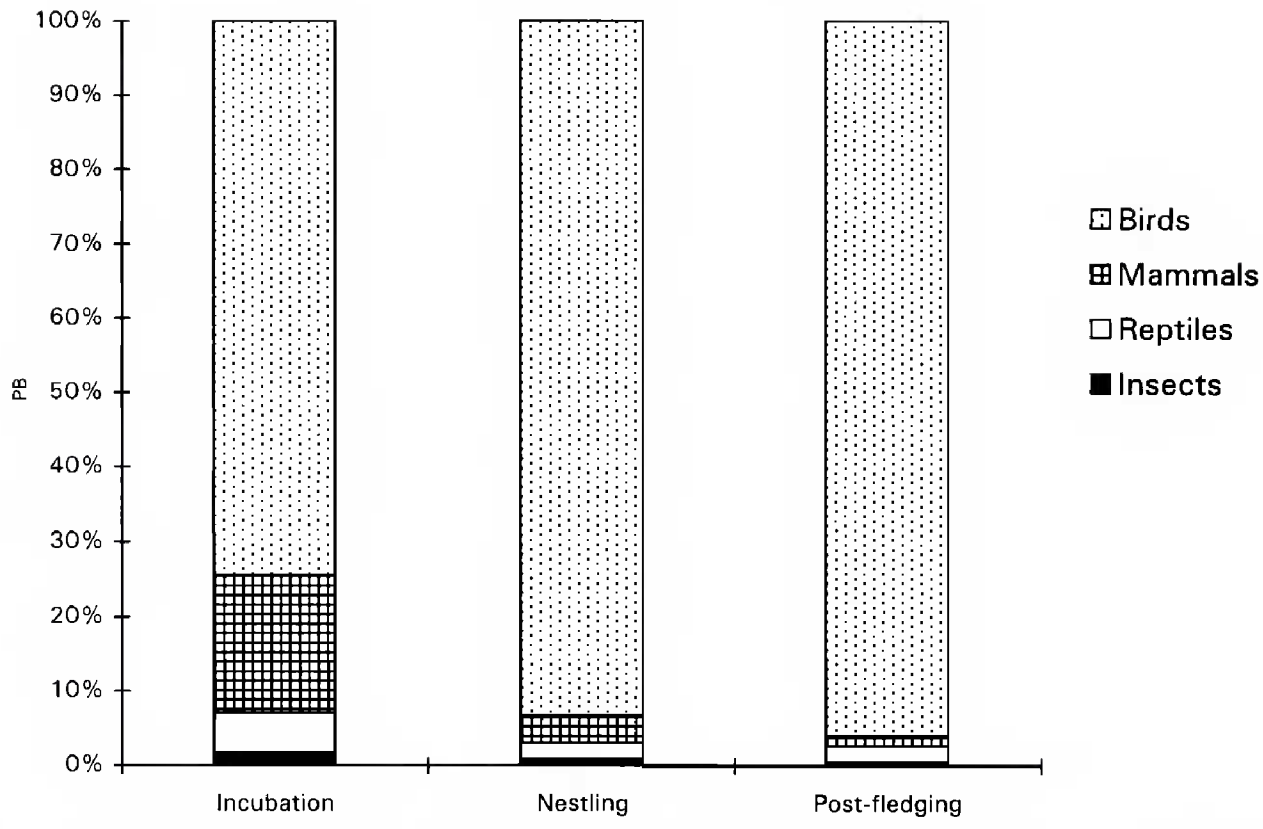

Figure 1. Diet of the Common Kestrel (*Falco tinnunculus*) in an urban area of Rome, Italy during the breeding season.

number of Feral Pigeons taken was positively correlated with the the number of Swifts (*Apus apus*) taken (r_s = 0.63, $P < 0.005$, $N = 20$). The number of passerines taken was negatively correlated with the number of rodents ($r_s = -0.70$, $P < 0.001$, $N = 20$) while the number of shrews (*Suncus etruscus* and *Crocidura* sp.) taken was positively correlated to numbers of rodents taken ($r_s = 0.60$, $P < 0.01$, $N = 20$). The number of Swifts taken was positively correlated with ancient urban areas ($r_s = 0.76$, $P < 0.005$, $N = 13$) and negatively with farmland areas ($r_s = -0.77$, $P < 0.005$, $N = 13$). By contrast, the number of rodents taken was positively correlated with farmland areas ($r_s = 0.93$, $P < 0.001$, $N = 13$) and negatively with ancient urban areas ($r_s = -0.77$, $P < 0.005$, $N = 13$). Monthly analysis of diets from pellets of a city-center nest showed a wide variation for some prey groups: insects were regularly taken throughout the year, but their biomass was always very low. Birds and reptiles were mainly taken in summer and small mammals in winter. The proportion in biomass of different prey groups varied significantly ($\chi^2 = 180.3$, df = 6, $P < 0.00001$) during the breeding season with rodents and lizards taken mostly during incubation, while birds predominated in the diet during the nestling and postfledging periods (Fig. 1).

DISCUSSION

The diet of the Common Kestrel in its typical habitat that consists of farmland areas with small woodland patches is generally composed of small mammals such as voles (*Microtus* spp.; Village 1990, Shrubb 1993). The increase in predation on reptiles and insects observed in Rome was probably due to the large availability of these prey in Mediterranean areas (Village 1990). An increase in birds in the diet of Tawny Owls (*Strix aluco*) has also been observed in European towns (Galeotti et al. 1991), probably because of the greater availability of birds and the decreased abundance of rodents in these areas (Galeotti 1994).

In some European cities, kestrels take prey far from their nest sites (Quere 1990, Romanowski 1996). In Rome, however, kestrels hunt near their nests during the nesting period most likely because a wide variety of prey is available both in the city center (birds, bats, and reptiles) and in the suburban open areas (small mammals, reptiles, and insects).

Predation on birds and small mammals, the two most important prey groups, varied in relation to the distance between open areas and the city center, and prey groups with similar ecological habits were correlated to each other and to the habitat types in hunting territories. Thus, both Swifts and Feral Pigeons were caught in archeological and ancient urban areas, where they were a readily available and conspicuous food source for city-center kestrels. By contrast, rodents and shrews were less common in these areas.

RESUMEN.—Estudiamos la dieta del cernícalo euroasiático *(Falco tinnunculus)* por dos años en la Roma urbana, Italia. Identificamos un total de 2361 items de presas en egagrópilas y restos de presas recolectados en 13 sitios de anidación y 7 perchas de invierno. Los cernícalos capturaron una gran variedad de presas, desde pequeños insectos incluyendo hormigas hasta aves grandes como palomas. Las aves y los murciélagos predominaron dur-

ante la estacion reproductiva mientras que los pequeños mamíferos y las lagartijas fueron mas comúnes en invierno. Los insectos estuvieron presentes en la dieta a lo largo del año, pero su biomasa fue muy baja. Las aves fueron capturadas predominantemente en áreas urbanas y los roedores en áreas agrícolas.

[Traducción de César Márquez]

ACKNOWLEDGMENTS

We are grateful to G. Bogliani, P. Galeotti, and B. Massa for comments on an early draft of the manuscript, and to E. Gizzi and A. Samà for checking the English language. Two anonymous referees provided useful suggestions and improved data presentation.

LITERATURE CITED

GALEOTTI, P. 1994. Patterns of territory size and defence level in rural and urban Tawny Owl (*Strix aluco*) populations. *J. Zool. London* 234:641–658.

———, F. MORIMANDO AND C. VIOLANI. 1991. Feeding ecology of Tawny Owls (*Strix aluco*) in urban habitats (northern Italy). *Boll. Zool.* 58:143–150.

MANGANARO, A., L. RANAZZI, R. RANAZZI AND A. SORACE 1990. La dieta dell'allocco, *Strix aluco,* nel parco di Villa Doria Pamphili (Roma). *Riv. Ital. Orn.* 60:37–52

QUERE, J.P. 1990. Approche du regime alimentaire du faucon crecerelle (*Falco tinnunculus* L. 1758) en milieu urbain (Paris *intra muros*) et durant la periode de reproduction. *Le Passer* 27:92–107.

ROMANOWSKI, J. 1996. On the diet of urban kestrels (*Falco tinnunculus*) in Warsaw. *Buteo* 8:123–130.

SALVATI, L. AND A. MANGANARO. 1997. Prime valutazioni su una popolazione urbana di gheppio *Falco tinnunculus. Avocetta* 21:142.

SHRUBB, M. 1993. The kestrel. Hamlyn, London, U.K.

VILLAGE, A. 1990. The kestrel. T. & A.D. Poyser, London, U.K.

Received 1 July 1998; accepted 4 February 1999